Reply to `On the two-parameter theory of solitons in spin systems' by Zhu-Pei Shi

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Reply to 'On the two-parameter theory of solitons in spin systems' by Zhu-Pei Shi

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The paper by Shi [1] does not actually offer clear answers to any of the objections that we have made in the comment [2] based on our earlier work [3]. All our objections can be understood from the relation presented there and repeated by Shi:

$$M = \hbar \sum |\beta|^2 = S_c/S \sum |\beta|^2 \tag{1}$$

where β is the coherent amplitude. We insist on three points:

(i) This relation leads to a finite (non-vanishing) result in the classical limit ($S \to \infty$; $\hbar \to 0$) only if β is proportional to $\sqrt{S}$ multiplied by a factor of order of unity. If this is the case then most of the factors $1/S$ or ε are missing from the equations for the renormalized amplitudes.

(ii) The expansion advocated by Shi and proposed by Huang *et al* [4] is in fact mostly the expansion of the classical expression for spins and misses most of the quantum corrections. This was demonstrated by us [5] and we have learned later that the same result was derived by Garbaczewski [6]. For a simple particular case it had already been demonstrated by de Azevedo *et al* [7].

(iii) The classical limit and continuum approximation are two independent processes so there is no *a priori* reason why the constants governing the two should be related [8].

We tried to demonstrate it by studying a simple example where the results contradict the initial assumption that $\eta = U\varepsilon$. We first use a normalization of β that Shi calls 'improper' and we call 'naive', although it is the one used in the earliest work by Pushkarov and Pushkarov [9].

We then indicate that the resolution should be obtained from the above expression applied in this case. The result is

$$\eta = a/\lambda_0 = \tau m/2S \tag{2}$$

which is also obtained by Shi [1]. We reason that since m ranges from zero to NS, it is not possible to establish any relation at all, while Shi claims that the assumption is consistent if the physical condition $m \simeq \sqrt{S}$ is fulfilled, yet no sound physical justification for this condition is given.

(We must stress in any case that Shi's claim that coherent amplitude cannot be normalized since coherent states are already normalized is not relevant since coherent states are normalized with any choice of coherent amplitudes [10].)

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Finally, since the condition for the validity of any approach is its capability to reproduce the existing results, it is important to notice that in the works based on two-parameter soliton theory [4] the classical limit fails to give the Landau–Lifshitz equation as it should [11].

We are aware that our approach is not an ideal one since the corrections of any order higher than $1/S$ are extremely complicated to obtain. For that reason, every effort helping to resolve the problems with bosonic representations is highly welcome and it is quite possible that a combination of our expansion and the two-component theory might lead to fruitful results. Yet, prior to its application one has to respond to the two following questions.

(i) What is the physical basis of relating the continuum approximation and the classical limit?

(ii) How can one obtain a diversity of equations all leading to the classical result [10] in the limit $\sqrt{\varepsilon} \to 0$?

The paper by Shi [1] is therefore only the first, as yet insufficient step in that direction.

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